

Fig. 13. Examples of several types of traps including: foothold (B, C, D, and F), snares (A and G), and hody-gripping trap (E).

lent option for use in residential areas or in situations where rodents and other small mammals causing damage are to be relocated. Various homemade designs can be constructed of wire mesh or wood, or wire mesh and plastic models can be purchased commercially. Certain models can be used to capture a variety of species while others are species specific. Some designs have doors at both ends, permitting visibility through the trap, thereby reducing trap shyness. Suggested baits, which depend on the species being trapped, include apple slices, sunflower seeds, peanut butter, and rolled oats.

Foothold traps are manufactured in several sizes and designs. Traditional foothold traps are commonly used for beaver, muskrat, and nutria control, while smaller sizes are used to capture tree and ground squirrels, rats, and marmots. Use of foothold traps, body-gripping traps, and snares is controversial; however, properly used they are effective and valuable wildlife management tools. Some states prohibit their use, whereas others sanction only traps with padded or offset jaws. Like other types of traps, there is potential to capture nontarget species; this danger can be lessened by using proper trap sizes, pan tension devices, break-away mechanisms, species-specific baits, and selecting trap locations that target the habits of the species being trapped (Conover 2002).

Body-gripping traps, primarily Conibears® (Fig. 13E), are used in water sets for beaver, muskrat, and nutria. Manufactured in a variety of sizes, they have the humane feature of killing quickly. These traps have a pair of opposing, heavy-gauge rectangular rods that close like scissors when triggered, killing the animal with a quick body blow. Conibear® traps are lightweight and easy to use. They can be placed at entrances of burrows and lodges and in dams, runs, and slides. Care should be taken when large Combear® traps are used due to the potential hazard to pets, children, and nontarget species. Some states prohibit the use of dry-land sets.

Somewhat similar body-gripping traps are available for moles and pocket gophers. For moles, the trap is placed over a section of the burrow that has been intentionally collapsed or compressed by the broad trap pan. The trap is activated when the mole traveling the runway pushes up on the compressed roof, trips the trigger pan, and is caught by

the loops or scissor action of the jaws. The harpoon trap is set in a similar fashion, but a spring-loaded harpoon spears the mole. For gophers, traps are placed into the exposed laterals or main tunnels of the burrow system. The openings can then either be left exposed or covered.

Snap traps are most commonly used for controlling rats and mice, and are used regularly in houses and other buildings. Advantages to using snap traps include: reduced danger to children or pets compared to some chemicals, easy recovery of killed animals, and no contaminants. Obstacles such as boxes or boards can be used to direct rodents to traps. Preferred baits include a mix of peanut butter and rolled oats, a small piece of bacon or apple, or a raisin. Snap traps can be used outdoors to capture small field rodents when only a few animals are involved or to capture animals for identification or population ecology studies.

#### Snares

Beaver can be captured as effectively with snares as with Conibear® or foothold traps (Weaver et al. 1985). Snares cost and weigh less than traps. Depending on whether the snare has a stop lock device to restrict tightening, the behavior of the captured animal and the length of time it's been held, as well as the part of the anatomy thar is being held, the animal may or may not die before it can be found and released. Snares are also effective in controlling small populations of rabbits. Animals must be traveling a well defined trail or using a specific entrance such as a hole in a fence. Snares are made of a loop of lightweight wire or cable incorporating a locking device to prevent the animal from backing off the tension in the cable. Snares can be set to kill the captured animal or to hold it by the leg or neck. Research is being conducted to make snares more species selective. State wildlife regulations should be checked to ascertain legality of usage.

#### Shooting

Shooting can be a selective method of eliminating individual pest mammals. Small-bore shotguns, rifles, and air guns are effective firearms. Some animals can be shot most effectively at night by using a spotlight with a red lens or night-vision equipment. Shooting is especially useful in controlling animals with low reproductive rates, such as porcupines. Local wildlife codes must be reviewed before shooting is used. Shooting at night, in particular with a spotlight, is not legal in some states.

# CARNIVORES AND OTHER MAMMALIAN PREDATORS

## Damage Assessment

Depredations of livestock by mammalian predators have been a concern to livestock producers for many centuries and continue to be an economic burden to some individuals. In the United States, 273,000 sheep and lambs were estimated to have been lost to predators in 1999 (U.S. Department of Agriculture 2000). Losses to predarors represented 36.7% of total losses to all causes and were valued at \$16.5 million to farmers and ranchers. The loss of goats to all predators was valued at \$3.4 million. In 1999, depredations of sheep and lambs were principally caused by coyotes (60.7%), dogs (15.1%), mountain lions (*Puma concolor*) [5.7%], and bobcats (*Lynx rufius*) [4.7%]. Cattle and calf losses to predators in the United States totaled

147,000 head during 2000 with an estimated value of \$51.6 million (U.S. Department of Agriculture 2001). Coyotes caused 64.6% of the losses to cattle and calves, followed by dogs (17.7%), and felids (mountain lions and bobcats) (7.5%). Losses of poultry to predators, although not well documented, are also believed to be substantial.

Predation by coyotes, wolves (Canis lupus), bears (Ursus americanus and U. arctos), and mountain lions can be a significant mortality factor for many ungulate species, mainly white-tailed deer, mule deer, black-tailed deer (O. h. columbianus and O. h. sitkensis), moose, caribou (Rangifer tarandus), and elk (Ballard et al. 2001). Predation on neonatal ungulates with losses exceeding 50% of the fawn cohort is commonly documented, especially in areas with coyotes (Barrett 1984, Hamlin et al. 1984, Whittaker and Lindzey 1999). Whether predation is a significant factor regulating ungulate populations and whether predator control can enhance ungulate populations continues to be a matter of debate among the scientific community and remains controversial within the general public (Connolly 1978, Messier 1991, Sinclair 1991, Boutin 1992, Ballard et al. 2001).

Predation by mammalian predators (generally smaller carnivores, such as red foxes [Vulpes vulpes], skunks [genera Conepatus, Mephitis, and Spilogale], raccoons, and mink [Mustela vison]) can be a major source of mortality to waterfowl (Sovada et al. 2001), grouse (subfamily Tetraoninae) (Hewitt et al. 2001, Schroeder and Baydack 2001), ring-necked pheasant (Phasianus colchicus) (Riley and Schulz 2001), quail (subfamily Odontophorinae) (Rollins and Carroll 2001), Neotropical migrant songbirds (Heske et al. 2001), and vulnerable ground-nesting species

such as sea turtles (Family Cheloniidae) (Ratnaswamy et al. 1997) and rare birds (e.g., ancient murrelets [Synthliboramphus antiquus]) (Hartman et al. 1997). Predation may affect nest success, juvenile survival, and adult survival. The red fox is possibly the most serious predator of waterfowl because it is capable of killing nesting hens as well as destroying eggs (Sargeant et al. 1984). Nest predation by raccoons and skunks can also impact nesting waterfowl, as well as threatened and endangered species.

Actually witnessing a predator killing a prey item is rare. Therefore, an accurate assessment of a predation event requires careful observational skills (O'Gara 1978a, Wade and Bowns 1984) (Fig. 14). O'Gara (1978a), Wade and Bowns (1984), and Acorn and Dorrance (1998) provide a thorough review of examination and identification of predators involved in depredation events. In general, upon arrival at a depredation site, personnel should approach the site carefully, and be sure not to trample tracks, feces, blood, vegetation, or other evidence that may assist in identifying the cause of death and the predator involved (if it is a predation event). Signs of predation and the possible predator involved should be searched for on the prey item and around the kill site. Extensive hemorrhaging usually is characteristic of predation. If predation is suspected, skinning the carcass (particularly around the neck, throat, and head) may provide clues to the predator involved by examination for subcutaneous hemorrhage, tissne damage, and the size, spacing, and location of tooth marks (O'Gara 1978a, Wade and Bowns 1984). Hemorrhaging occurs only if the skin and tissue damage occurred while the animal was still alive. Animals that die



Fig. 14. Bobcat tracks surround a deer carcass with evidence that the bobcat fed. More investigation is required to ascertain if the bobcat killed the deer or scavenged it.

from causes other than predation normally do not show external or subcutaneous bleeding, although bloody fluids may be lost from body openings (O'Gara 1978a, Wade and Bowns 1984). The cause of death is best evaluated if the carcass is examined when fresh (Wade and Bowns 1984). Tracks and scats alone are not proof of depredation or of the species responsible, only that a particular predator is in the area. Other signs associated with a depredation event include nervous or alert livestock, injured livestock, or females calling or searching for young (Acorn and Dorrance 1998). Thus, all evidence must be considered to ascertain if the death was due to a predator and the predatory species responsible. Many predators will scavenge carcasses; hence, scavenging should not be confised with predation.

## Species Damage Identification

# Badgers

American badgers are opportunistic feeders, but prey mostly on mice, prairie dogs, marmots, pocket gophers, and ground squirrels, and occasionally on rabbits, especially young (Messick 1987, Lindzey 1994). Badgers destroy nests of ground-nesting birds and occasionally kill small lambs and poultry. Their burrows in a field may slow harvesting or cause damage to machinery, and their digging can damage earthen dams or dikes (Dolbeer et al. 1994b, Lindzey 1994). Badger tracks are similar to those of covotes but, on closer examination, badger tracks appear to be pigeon-toed and impressions from the long toenails are apparent under most conditions (Dolbeer et al. 1994b). Signs of digging near prey remains may be the best evidence of badger activity. Damage management techniques include fencing, frightening devices, traps (foothold), snares, and shooting.

#### Bears

Conflicts with black and brown bears occur when they prey on livestock, feed on field crops, destroy beehives, or become a general nuisance around campgrounds, cabins, landfills, and garbage dumps (Hygnstrom 1994, Jonkel 1994). Bears usually kill by biting the neck or by slapping the victim, leaving a characteristic mauled and mntilated carcass (O'Gara 1978a, Dolbeer et al. 1994b). The neck may be broken as well (Acorn and Dorrance 1998). Bears will trample the vegetation and often vomit or defecate near the carcass. Large prey items are usually opened ventrally and the heart and liver consumed (Bowns and Wade 1980); the udder of lactating females may be consumed. The intestines often are spread around the kill site, and the animal may be partially skinned where the carcass is fed upon (Dolbeer et al. 1994b). Smaller livestock such as sheep and goats may be consumed almost entirely, with only the rumen, skin, and large bones remaining (Acorn and Dorrance 1998). Bears use their feet while feeding and do not slide the prey around as do coyotes (O'Gara 1978a). However, if the prey is brought down in the open, the carcass may be dragged to a more secluded spot before or after initial consumption (Acom and Dorrance 1998).

Brown bears have a feeding and killing pattern similar to that of black bears (Jonkel 1994), but they usually cover their prey after the initial feeding, whereas black bears rarely cover the prey item (Acorn and Dorrance 1998). Cattle are usually killed by a bite through the back of the

neck and large prey often has claw marks on the flanks or hams (Dolbeer et al. 1994b). The back of an ungulate is often broken in front of the hips where the bear pushes the animal down. Young calves are sometimes bitten through the forehead. Sheep may readily stampede at the onset of a bear attack and injure or kill themselves by tripping on downed timber or running over cliffs (Jonkel 1994). Jonkel (1994:20) states, "most bear depredations are easily identified, especially if there is wet or soft ground in the area. Bears are not sneaky—they march right in and take what they consider is theirs."

Black bears can canse significant damage to trees, especially in second-growth forests (Noble and Meslow 1998, Partridge et al. 2001). Damage can be recognized by the large, vertical incisor and claw marks on the sapwood and ragged strips of hanging bark, or branches broken to feed on fruit (Dolbeer et al. 1994b, Hyngstrom 1994). Most bark damage occurs from May to July (Packham 1970). Damage to field crops can also be substantial, with corn and oats being preferred crops (Hygnstrom 1994). Damage management techniques include supplemental feeding. aversive conditioning, fencing, frightening devices, repellents, traps (foothold and live traps), foot snares, and hunting with dogs.

## Coyotes, Wolves, and Dogs

These canids prey on animals ranging in size from big game and livestock to rodents, native birds, and poultry (Carbyn 1987, Voigt and Berg 1987). Coyotes are the most common and most serious predator of livestock in the western United States (U.S. Department of Agriculture 2000, 2001) and are becoming more of a problem throughout the eastern United States. Coyotes normally kill livestock with bites to the neck and throat, but may pull the animal down by attacking the side and hindquarters (O'Gara 1978a, Wade and Bowns 1984, Green et al. 1994, Acorn and Dorrance 1998). The rumen and intestines are not eaten, but often removed and dragged away from the carcass. When canids kill small lambs, their upper canine teeth can penetrate the top of the neck or the skull (Wade and Bowns 1984). Calf predation by coyotes is most common when calves are young. Calves attacked, but not killed, exhibit wounds to the flank, hindquarter, or front shoulder (Wade and Bowns 1984). Deer that are killed are completely dismembered and earen (Dolbeer et al. 1994b). With increased urbanization, complaints of pets being killed by coyotes have increased and attacks on humans (mainly children) are an increasing concern in urban areas (e.g., Howell 1982, Baker and Timm 1998). Agricultural producers using drip irrigation systems report that coyotes chew holes in plastic pipe and disrupt irrigation (Werner et al. 1997). Fruit crops, particularly watermelons, can also be consumed or damaged by coyotes (Green et al. 1994).

Wolves prey mainly on larger ungulates such as deer, caribou, moose, elk, and cattle. Cattle, especially calves, are most vulnerable to wolf predation (Paul and Gipson 1994, Acorn and Dorrance 1998). However, predation on livestock is rare (Fritts et al. 1992). Wolves usually kill ungulates by attacking the hindquarters or by seizing the flanks (Paul and Gipson 1994). Slash marks made by the canine teeth may be found on the rear legs and flanks (Dolbeer et al. 1994b). When the victim is badly wound-

ed and collapses, wolves will often disembowel the animal (Paul and Gipson 1994). Wolves usually eat the viscera and hindquarters first. Most of the carcass is consumed and large bones may be chewed or cracked open (Acorn and Dorrance 1998). Wolves may carry parts of the carcass to dens or rendezvous sites for pups to consume.

Domestic dogs can be a serious problem to livestock. especially to sheep pastured near cities and suburbs (Green and Gipson 1994). Dogs may be indiscriminate as to how and where they attack, but often attack the hindquarters. flanks, and head, and rarely kill as effectively as coyotes (Dolbeer et al. 1994b, Green and Gipson 1994). O'Gara (1978a) considered dogs to be "sloppy" killers, often slashing and tearing victims and leaving many cripples (Acom and Dorrance 1998). If dogs eat sheep or big game, they normally eat the hams and often vomit near the site (O'Gara 1978a). Normally little flesh is consumed (Green and Gipson 1994, Acom and Dorrance 1998). Dogs generally wound the animal in the neck and front shoulders; the ears often are badly torn (Dolbeer et al. 1994b). Attacking dogs often severely mutilate the prey (Acorn and Dorrance 1998); skinning the animal will often reveal 80% of the body bruised by bites that did not penetrate the skin (O'Gara 1978a).

Coyote and dog tracks are similar but distinguishable (Dolbeer et al. 1994b). The larger size of wolf tracks often separates them from coyotes and dogs. Coyote tracks are more oval in shape and compact than dogs (Green et al. 1994, Acorn and Dorrance 1998). Dog tracks are round with the toes spread apart and toenail marks usually are visible on all toes (Dorsett 1987). Coyote tracks tend to follow a straight line more closely than dogs (Green et al. 1994). Damage management techniques include good livestock husbandry practices, livestock protection collars, guard animals (dogs, llamas, and donkeys), electronic training collars, lencing, frightening devices, reproductive interference, M-44s, aerial hunting, calling and shooting, denning, traps (foothold), and snares.

#### **Felids**

Felids that cause damage are primarily mountain lions, bobcats, and Canada lynx (Lynx canadensis). Mountain lions are almost exclusively carnivorous and prey on native ungulates, mainly deer and elk, and domestic stock, particularly horses, sheep, goats, and cattle (Lindzey 1987). They will also eat rodents and other small mammals when available (Dolbeer et al. 1994b). Livestock depredations are often random and unpredictable; it is not uncommon for several animals to be killed in a short period of time (Knight 1994a). A lion killing 5–10 sheep in a single night has been documented (Shaw 1983).

Lions typically kill sheep, goats, calves, and deer with bites to the top of the neck or head (Knight 1994a, Acom and Dorrance 1998). Lions may also sever the vertebral column and break the neck of its prey. Lions kill in a similar manner as bobcats, but the tooth punctures of a lion kill will be larger (0.63–0.79 cm) and more round than bobcat punctures (O'Gara 1978a). Strips of skin will also be present at the kill site from the lacerations caused by the lion's claws. Lions usually feed first upon the shoulders of their prey (O'Gara 1978a). The stomach generally is untouched (Acom and Dorrance 1998). The large leg bones of prey may be crushed and ribs may be broken (Dolbeer et al.

1994b). Often a lion will cover its kill with soil, leaves, grass, and other debris (Knight 1994a) and may return to feed on a kill for 3-4 nights. They normally uncover the kill at each feeding and move it 10-25 m before covering the carcass again. After the last feeding the remains may be left uncovered (Shaw 1983).

Lion tracks may be difficult to observe except in snow or sandy or wet soil. Adult lion tracks are approximately 10 cm across and have a distinguishable 3-lobed heel pad (Knight 1994a). Lions have retractable claws; therefore, no claw marks will be evident. Large dog tracks could be confused with lion tracks. However, dog tracks normally show distinctive claw marks, are less round than lion tracks, and have different heel pad marks (Dolbeer et al. 1994b).

Bobcats are opportunistic predators, feeding mainly on rabbits, rodents, and birds (Rolley 1987). Occasionally they will kill and consume poultry, sheep, goats, small dogs, house cats, and, rarely, calves (Virchow and Hogeland 1994). Bobcats usually kill their prey by biting the back of the neck or base of the skull (O'Gara 1978a). Bobcats often may be carried a short distance by an adult deer before the cat can complete the kill. Prey usually die of suffocation and shock, or from dislocated neck vertebrae. Hair and strips of hide may be found at the site where the cat first attacked. Scratches are usually evident on the shoulders, back, or sides of the prey (Virchow and Hogeland 1994). Bobcats often attack and kill lambs by holding the animal with its claws while biting the neck or head. Skulls may be fractured, but not crushed like those bitten by coyotes (O'Gara 1978a). The hindquarters of deer or sheep usually are eaten first by bobcats, although the shoulder, neck, or flank also may be consumed first (Dolbeer et al. 1994b). The rumen is often untouched. Carcasses are usually covered before being left and may be buried under leaves, snow, or soil, or the remains may be carried and cached under shrubs (O'Gara 1978a, Virchow and Hogeland 1994). Bobcats reach out 30-35 cm when covering their kill, whereas mountain lions reach out to 90 cm (Young 1958). Poultry usually are killed by biting the head and neck (Young 1958); the heads usually are eaten. Tooth punctures from a bobcat are similar to those of a coyote, but tend to slash more than those of canids (O'Gara 1978a). The distance between the canine teeth marks will also help distinguish a mountain lion kill from a bobcat kill: 3.8 cm versus 1.9–2.5 cm, respectively (Wade and Bowns 1984). Lynx rarely kill livestock and are mainly a specialist on snowshoe hares (Lepus americanus) (Quinn and Parker 1987). Bobcat and lynx feces are similar in size and shape. In areas inhabited by both species, careful examination of the tracks will help identify the species responsible for a depredation event. The lynx has larger feet with much more hair, and the toes tend to spread more than those of bobcats (Dolbeer et al. 1994b). Small Neotropical felids in the United States, such as the ocelot (Felis pardalis), margay (F. wiedii), and jaguarundi (Herpailurus yagouaroundi), pose little threat to livestock, but may occasionally kill a chicken. They mostly consume native birds, small mammals, and reptiles (Tewes and Schmidly 1987). Damage management techniques include fencing, frightening devices, traps (foothold), snares, and hunting (by calling and shooting, and with dogs).

#### Foxes

Gray (Urocyon cinereoargenteus) and red foxes feed primarily on rabbits, hares, small rodents, poultry, birds. fruit, and insects (Voigt 1987). Although poultry is the most common domestic prey, red foxes (and to a lesser extent gray foxes) may prey on livestock, mainly lambs and kids (Phillips and Schmidt 1994). Predation of poultry by swift (V. velox) and kit (V. macrotis) foxes is almost nonexistent (O'Farrell 1987, Scott-Brown et al. 1987). Arctic foxes (Alopex lagopus) in Iceland may prey on livestock (Garrott and Eberhardr 1987). Foxes usually attack the throat of lambs and kids, but kill some prey by multiple bites to the neck and back (Wade and Bowns 1984, Dolbeer et al. 1994b). Foxes do not have the body or jaw power of larger canids; thus, they are unable to seize and immobilize large prey and multiple bites may be evident (Wade and Bowns 1984). Foxes generally eat the viscera first and may begin feeding through the ribs (Wade and Bowns 1984). Foxes killing fowl usually leave behind only a few drops of blood and feathers and carry the prey from the kill location (Phillips and Schmidt 1994). Eggs usually are opened enough to allow the contents to be licked out and are often left beside the nest (Dolbeer et al. 1994b).

When attempting to identify the predator of a depredated animal, note the canine teeth are smaller and the spacing is narrower in foxes compared to coyotes (Wade and Bowns 1984). Red fox tracks may resemble coyote tracks, but fox tracks are generally smaller than coyote tracks and have a shorter stride. Gray fox tracks are slightly smaller than those of red foxes. Damage management techniques include guard dogs, fencing, frightening devices, M-44s, aerial hunting, traps (foothold), snares, calling and shooting, and hunting dogs.

## **Opossums**

Virginia opossums (*Didelphis virginiana*) are primarily insectivorous and omnivorous and prefer eating fish, crustaceans, insects, mushrooms, fruits, vegetables, eggs, and carrion (Seidensticker et al. 1987). Opossums will occasionally raid poultry houses and generally kill one chicken at a time, often mauling the victim (Dolbeer et al. 1994b). Eggs will be mashed and messy; the shells often are chewed into small pieces and left in the nest (Dolbeer et al. 1994b). Young poultry or game birds are consumed entirely. Opossums in urban areas may be a nuisance where they get into garbage cans, compost piles, bird feeders, and pet food (Jackson 1994a). Damage management techniques include fencing, traps (foothold and live traps), shooting, and hunting dogs.

#### Raccoons

Raccoons are one of the most omnivorous predators, eating mice, small birds, snakes, frogs, insects, crawfish, grass, berries, acoms, com, melons, turtle eggs, and a variety of grain crops (Sanderson 1987). They are notorious for raiding fields of sweet com and tearing ears off the plants. In watermelon fields, raccoons will dig into the melon and scoop out the contents with their front paws (Boggess 1994). In urban areas, raccoons readily raid garbage cans and dumps. They can cause damage to houses and buildings when trying to gain access to atrics and chimneys. Agricultural fields and gardens near wooded

areas may experience severe damage from raccoons (Dolbeer et al. 1994b). Raccoons may prey on eggs and young of ground- and cavity-nesting birds, or raid artificial nesting structures (Boggess 1994). Predation by raccoons on nests of sea turtles (Ratnaswamy et al. 1997), ancient murrelets (Hartman et al. 1997), and other threatened and endangered species is a growing concern for conservation efforts.

Raccoons rarely kill small lambs. When they do, they usually grab their prey with their paws and bite the neck (O'Gara 1978a). Similar to the bites of a fox, bites from a raccoon atrack usually encircle the whole neck (O'Gara 1978a). Skinning the carcass will reveal bruises where the prey was grabbed, but not deep scratches like bobcats. Raccoons often feed on a carcass at the loins or by making a small hole in the side of the carcass and pulling the viscera from the body cavity to consume it (O'Gara 1978a).

Raccoons occasionally raid poultry houses and may kill many birds in a night (Dolbeer et al. 1994b). The heads of adult birds are usually bitten off and left (Boggess 1994). The breast and crop may be torn and chewed, and the entrails may be consumed (Boggess 1994). Young birds in pens or cages may be killed or injured when the raccoon grabs a bird through the wire mesh and tries to pull it from the cage. Eggs may be removed and eaten away from the nest, or consumed on the spot with only shell fragments remaining.

Raccoons leave a distinctive 5-toed track resembling a small human hand print (Boggess 1994). Tracks usually are paired, and the left hind foot is placed beside the right forefoot. Raccoon and opossum tracks can be difficult to distinguish in soft sand where toe prints are not distinctive. Damage management techniques include fencing, traps (foothold and live traps), shooting, and hunting dogs.

# Skunks

Skunks are opportunistic omnivorous predators consuming insecrs (particularly grasshoppers, beetles, and crickets), bird eggs, mice, and occasionally rats and cottontail rabbits (Rosatte 1987, Knight 1994b). Skunks become a nuisance when they dig small (7–10 cm), cone-shaped holes, or turn over patches of earth in lawns, gardens, and golf courses in search of insect grubs (Dolbeer et al. 1994b). They may burrow under porches and buildings. Their odor is a common complaint when they take up residence under human dwellings. Skunks may damage beehives when attempting to eat the bees.

Skunks are major predators of waterfowl nests. Nonlethal techniques to reduce skunk predation on waterfowl nests have had limited success (Greenwood and Sovada 1996, Greenwood et al. 1998). Skunks occasionally kill domestic poultry and eat eggs, but usually will not climb fences to raid poultry houses (Knight 1994b). When skunks kill poultry, they generally kill only 1–2 birds and often maul rhem (Dolbeer et al. 1994b). Eggs usually are opened at one end with the edges crushed inward as the skunk punches its nose into the hole to lick out the contents (Knight 1994b). When in a more advanced stage of incubation, eggs are likely to be chewed in small pieces. Eggs may be removed from the nest, but are rarely moved far (Dolbeer et al. 1994b).

Inhabited dens can be recognized by fresh droppings containing undigested insect parts near the mound or hole (Dolbeer et al. 1994b). Dens usually have a characteristic skunk odor, although the odor may not be strong. Tracks are relatively distinctive with both front and rear feet having 5 toes with claw marks often visible (Knight 1994b). The heel of the fore feet may not be visible and in some cases the fifth toe may not be obvious (Knight 1994b). Damage management techniques for skunks include fencing, repellents and fumigants, traps (foothold and live traps), and shooting.

#### Weasels and Mink

Weasels (Mustela erminea, M. frenata, M. nivalis) feed primarily on insects and small rodents, and occasionally prey on birds, fish, amphibians, reptiles, eggs of groundnesting birds, and berries (Fagerstone 1987). Mink are generalists and feed on a variety of maminalian prey, mainly small rodents, muskrats, and lagomorphs. Mink will also prey upon fish, birds, and invertebrates (Eagle and Whitman 1987). Weasels and mink have a similar killing pattern in which they bite the prey item through the skull and upper neck. When feeding on muskrats, mink will often make an opening at the back or side of the neck. As the mink consumes the flesh, ribs, and pieces of the adjacent hide, the head and hindquarters are pulled through the same hole, skinning the animal (Dolbeer et al. 1994b). McCracken and Van Cleve (1947) noted a similar feeding pattern by weasels when consuming small rodents.

Weasels and mink will raid poultry houses at night and kill or injure domestic fowl (Henderson 1994b). They often kill many birds by biting them in the head and often eat only the heads of the victims, but will consume the body as well. Rat predation usually differs from weasel predation in that portions of the chicken are eaten and carcasses are dragged into holes or concealed places (Henderson 1994b). Waterfowl eggs destroyed by weasels tend to be broken at the ends with openings 15–20 mm in diameter (Teer 1964). Close examination of shell fragments will often disclose finely chewed edges and tiny tooth marks left by a weasel (Rearden 1951).

Weasels den in burrows in the ground, under rocks or brush piles, in barns, or in piles of stored hay (Dolbeer et al. 1994b). The den itself is an enlarged chamber (3.5–5.0 cm) lined with dry grass and the fur of previous kills (Fagerstone 1987). Mink may use cavities in roots of trees, rocks, brush piles, logjams, and beaver lodges (Eagle and Whitman 1987). Mink will also use abandoned burrows of other animals as den sites, especially those of muskrats. Damage management techniques include fencing and trapping (Conibear<sup>®</sup>, foothold, and live traps).

## Feral Cats

Feral cats are house cats living in the wild, although even house cats can cause damage by killing native small mammals and songbirds. Feral cats are opportunistic predators that prey on songbirds, ducks, pheasants, rabbits, quail, rodents, insects, reptiles, amphibians, and fish (Fitzwater 1994). Similar to feral dogs, feral cats are often described as "sloppy" killers, with parts of their prey strewn about when feeding. Cats generally consume the meaty portions of large birds, leaving loose skin with feathers attached (Dolbeer et al. 1994b). Small birds generally are consumed and only the wings and scattered feathers remain. Cats usually leave tooth marks on every

exposed bone of their prey. Nesting birds particularly are vulnerable to cat predation and cats can exact a heavy toll on bird populations (Churcher and Lawton 1987, Jurek 1994, Coleman et al. 1997). Unlike domestic house cats, feral cats often are extremely wary of humans. Damage management techniques include fencing, frightening devices (dogs), traps (foothold and live traps), snares, and shooting.

## Control Techniques

Protecting livestock and poultry from predators is a complex endeavor, with each case requiring an assessment of the legal, social, economic, biological, and technical aspects with no one technique solving the problem in all circumstances (Knowlton et al. 1999). Successful resolution of conflicts with predators involves an analysis of the efficacy, selectivity, and efficiency of management scenarios. Control techniques may be considered either corrective (after a depredation event) or preventive (before the event). Selectivity of the technique is extremely important when attempting to actually solve the depredation problem. General population reduction may not solve the depredation problem (e.g., Conner 1995), but techniques (e.g., livestock protection collars, calling and shooting) that selectively remove the offending individual (Sacks et al. 1999a,b; Blejwas et al. 2002) are preferred over nonselective techniques (e.g., traps or snares) that the predators may avoid (Sacks et al. 1999a). Identifying the "problem" animal can be difficult (Linnell et al. 1999). Methods that are more benign in their effects on other species are preferred to those creating greater perturbations (Knowlton et al. 1999).

A diverse array of techniques (nonlethal and lethal) has been used to prevent or deter depredations on livestock and poultry (Fall 1990, Green et al. 1994, Knowlton et al. 1999). Regrettably, these techniques do not often carry over to protecting wildlife resources. Some techniques (e.g., fencing, lethal removal) developed for protection of domestic commodities may reduce depredations on natural resources (Ratnaswamy et al. 1997, Garrettson and Rohwer 2001), but are generally limited to small-scale applications. Most nonlethal procedures are within the operational purview of the agricultural producer. While there are reports of success with some methods, failures are common, few have been subjected to critical evaluation or testing, and none has proven a panacea (Knowlton et al. 1999).

## Livestock Husbandry Practices

Numerous livestock management practices have been suggested as a means of reducing depredation losses (Robel et al. 1981, Wagner 1988, Acom and Dorrance 1998). Some of the most common practices include: (1) confining or concentrating flocks during periods of vulnerability (e.g., at night or during lambing), (2) using herders, (3) shed lambing, (4) removing livestock carrion from pastures, (5) synchronizing birthing, and (6) keeping young animals in areas with little cover and in proximity to human activity (Knowlton et al. 1999). These procedures generally require additional resources and effort, and frequently only delay onset of predation, or may have undesirable side effects (Knowlton et al. 1999). For these methods to be effective, producers must develop strategies for

their own situations. Producers must also realize that economic advantages of modifying their husbandry practices may be difficult to demonstrate (Knowlton et al. 1999), but can assist in herd management and production. Surveys indicate that producers use herding (11%), night penning (47%), and shed lambing (51%) in their livestock management operations (U.S. Department of Agriculture 2000).

## Guard Dogs

Use of guard dogs to deter coyotes from livestock has been a traditional method of damage control used by many sheep producers, particularly in fenced pastures (Acorn and Dorrance 1998) (Fig. 15). In several western states, about 32% of producers surveyed used guard dogs to protect their flocks (U.S. Department of Agriculture 2000). In Colorado, Andelt (1992) reported that 11 sheep producers estimated their guard dogs saved an average of \$3,216 of sheep annually and reduced their need for other predator control techniques. Dog breeds most commonly used as livestock guardians include Great Pyrenees, Komondor, Akbash, Anatolian, and Maremma. While there does not appear to be one breed of dog that is most effective, livestock producers rated the Akbash breed as most effective at deterring predation because it is more aggressive, active, intelligent, and faster (Andelt 1999). The Great Pyrenees is the most common guard dog breed in Alberta (Acorn and Dorrance 1998). Studies investigating efficacy of guard dogs have shown the dogs to be effective in some situations and ineffective in others (Linhart et al. 1979, Coppinger et al. 1983, Green et al. 1984, Green and Woodruff 1987, Conner 1995, Andelt and Hopper 2000).

This disparity may be due to inherent difficulty of guard dogs to effectively protect large flocks dispersed over rough terrain and in areas where thick cover conceals approaching predators. Training and close supervision of the dogs seem to be important steps contributing to the success of this technique (Acorn and Dorrance 1998). Some poorly trained or minimally supervised guard dogs have killed sheep and lambs, harassed or killed wildlife, and threatened people that intrude upon their territory. However, not all guard dog failures or undesired behaviors stem from poor training or supervision. There is considerable behavioral diversity within even a particular litter of guard dog pups; some turn into valuable and effective guard animals, while others do not, despite similar training and effort. Use of guard dogs precludes use of other control devices (e.g., traps, snares, M-44's) and techniques (e.g., calling and shooting) (Knowlton et al. 1999). Dogs can be killed or injured by poisons, snares, and traps used for predator control (Acorn and Dorrance 1998).

#### Guard Llamas

Use of llamas for protecting livestock from predators takes advantage of their evolution with predators and defensive capabilities. Using llamas as guard animals is growing in popularity (Markham et al. 1993) with about 22% of western producers surveyed using them (U.S. Department of Agriculture 2000). Studies have found llamas to be a practical and effective tool to deter predators, mainly coyotes and dogs, from depredating livestock (Franklin and Powell 1994, Meadows and Knowlton 2000). Llamas can be kept in fenced pastures with sheep



Fig. 15. A Great Pyrenees guard dog protecting sheep.

or goats, do not require any special feeding program, are relatively easy to handle, and live longer than guard dogs (Knowlton et al. 1999). Although guard animals may not deter coyotes from habiting the immediate area of livestock, they may change the behavior and activity patterns of predators when in those areas (Knowlton et al. 1999). Traits that may be useful in selecting a llama for use as a livestock guardian include leadership, alertness, and body weight (Cavalcanti and Knowlton 1998).

## Guard Donkeys

Donkeys have also been used as livestock guardians (Green 1989, Acorn and Dorrance 1998), with about 6% of producers in the western United States using donkeys as a management tool (U.S. Department of Agriculture 2000). The protective behavior of donkeys apparently stems from their dislike of dogs. A donkey will bray, bare its teeth, chase, and try to kick and bite coyotes and dogs (Acorn and Dorrance 1998). Recommendations on selection of donkeys as livestock guardians include using only a jenny or gelded jack (intact jacks are too aggressive towards livestock), placing one donkey per flock or group and keeping other donkeys or horses away to prevent the guard donkey from bonding with any animal but those to be protected. Furthermore, donkeys should be introduced to the livestock about 4-6 weeks prior to the onset of anticipated predation events to properly bond with the group (Acorn and Dorrance 1998). Donkeys are most effective in small, fenced pastures.

## Supplemental Feeding

Supplemental feeding as a nonlethal technique to divert a predatory species from a vulnerable commodity for a period of time has received some attention. Many predators will readily consume food provisioned by humans. Greenwood et al. (1998) found that while skunks and other predators responded to supplemental feeding, depredations on waterfowl nests remained unchanged. They concluded that food provisioning had limited value for managing depredations on waterfowl nests in the Prairie Pothole region of North America because the predator community was large and complex. In the Pacific Northwest, black bears damage coniferous trees by feeding on sapwood during spring (Noble and Meslow 1998, Partridge et al. 2001). Collins (1999) reported that damage to trees by black bears was highest in areas where bears did not receive supplemental feeding (i.e., pellet feeders). Supplemental feeding of bears reduced damage to the trees with apparently no long-lasting effect on bear condition or productivity (Partridge et al. 2001).

#### Fencing and Barriers

Livestock, poultry, crops, and waterfowl and sea turtle eggs may be protected from predators with a properly constructed and located barrier. About 36% of livestock producers surveyed reported they used fencing to reduce predator losses (U.S. Department of Agriculture 2000). Barriers may take the form of an exclosure, electric fence, nest screen, or even a moat (e.g., DeCalesta and Cropsey 1978, Linhart et al. 1982, Shelton 1984, Nass and Theade 1988, Melvin et al. 1992, Lokemoen and Woodward 1993, Ratnaswamy et al. 1997). Standard fencing will not keep most predators from entering gardens or poultry ranges

because they learn to jump over or dig under such fences. Many large predators (coyotes, foxes) may be deterred or excluded by adding an electrified single-wire strand charged by a commercial fence charger along a wire mesh fence. The electrified wire should be placed 20 cm outside of the main fence line and 20 cm above the ground (Dolbeer et al. 1994b). A fence 1.5 m high with 9 to 12 alternating ground and charged wires spaced 10–15 cm apart is an effective barrier against coyotes (Gates et al. 1978, Acom and Dorrance 1998). A woven-wire fence that is more versatile, longer lasting, and can be tightened more than conventional wire mesh can also be used (Acom and Dorrance 1998).

Skunks may be deterred from entering a poultry area with a 0.9-m high wire mesh fence extending 0.6 m above ground and 0.3 m below the surface; a 15-cm length of the portion below ground should be bent outward at right angles and buried 15 cm deep (Dolbeer et al. 1994b). Mink and weasels may be excluded from barns or coops by covering all openings larger than 2.5 cm with metal or hardware cloth. Asiatic black bears (Ursus thibetanus) in Japan were successfully deterred from entering crop fields and apiaries with an electric fence (Huygens and Hayashi 1999). Installation costs usually preclude use of fences for protecting livestock in large pastures or under range conditions. For wildlife resources, fencing may be best suited to protecting waterfowl nests or high-value commodities in small areas (e.g., sea turtle nests, Ratnaswamy et al. 1997). If electric fencing is used, the behavior of the wildlife resource being protected should also be considered (Trottier et al. 1994) and modifications to the design may assist in protection efforts without deleterious impacts on the species being protected (Pietz and Krapu 1994).

## Frightening Devices

Devices such as lights, distress calls, loud noises, scarecrows, plastic streamers, propane cannons, aluminum pie pans, and lanterns have been used to frighten predators (Acom and Dorrance 1998). Most testing has focused on devices which periodically emit bursts of light or sound to deter coyotes from sheep in fenced pastures and openrange situations (Linhart 1984, Linhart et al. 1984, 1992), but the benefits are often short-lived (Bomford and O'Brien 1990, Koehler et al. 1990). All of these devices can provide temporary relief from damage or in deterring predators, but habituation is common (Acom and Dorrance 1998). Changing the location of devices, the pattern of the stimuli, or combining several techniques can prolong the frightening effect (Linhart et al. 1992). Linhart (1984) reported that a combination of warbling-type sirens and strobe lights reduced coyote predation on lambs by 44%. These battery-operated devices were activated in the evening by a photocell set on a schedule of 10-second bursts at 7- to 13-minute intervals. Pfeifer and Goos (1982) found use of propane exploders delayed or prevented lamb losses to coyotes for a period of time. Similarly, VerCauteren et al. (2003a) reported no kills during the lambing period when flocks were bedded near predatoractivated frightening devices. A recent development used to deter wolf predation is the Radio Activated Guard (RAG). The RAG is activated only when a radiocollared wolf is in the vicinity, preventing habituation of the animal to the lights and siren. The RAG has application only in

areas with radio-marked animals, but can deter endangered predators from causing problems to livestock producers. In general, use of frightening devices is not widespread, with only about 6% of producers using frightening devices (U.S. Department of Agriculture 2000). The use of sirens and strobe lights at night near people is generally not acceptable (Knowlton et al. 1999).

## Repellents and Aversive Conditioning

Presently, there are no commercially available repellents that effectively deter predation (Knowlton et al. 1999). A variety of noxious gustatory, olfactory, and irritating compounds have been tested with a few (e.g., thiabendazole, pulegone, cinnamaldehyde, allyl sulfide) reducing food consumption among predators (Hoover and Conover 1998, 2000; Ternent and Garshelis 1999). While quinine hydrochloride and capsaicin may discourage coyotes from chewing on irrigation hoses (Werner et al. 1997), there is little information demonstrating these repellents deter predation (Lehner 1987, Burns and Mason 1997). Polson (1983) used thiabendazole to condition black bears to avoid beehives. Ternent and Garshelis (1999) reported that black bears could be discouraged from consuming meals-ready-to-eat (MREs) on a military reservation by treating the MREs with thiabendazole. Skunks may be repelled from areas with ammonia-soaked cloths or moth balls (Knight 1994b).

Conditioned taste aversion, using lithium chloride, to reduce coyote predation on sheep has received much attention. Results of studies were mixed, with some reporting success (Gustavson et al. 1974, Ellins and Martin 1981, Gustavson et al. 1982, Forthman-Quick et al. 1985a,b), while others were either unable to replicate those findings or found lithium chloride to be ineffective in field situations (Conover et al. 1977, Burns 1980, Bourne and Dorrance 1982, Burns 1983, Burns and Connolly 1985). While lithium chloride reduces prey consumption, it apparently does not deter the act of predation. Ten years after extensive field trials using lithium chloride (Gustavson et al. 1982, Jelinski et al. 1983), a survey of the same sheep producers revealed that only one producer still used it (Conover and Kessler 1994). Available evidence suggests that conditioned taste aversions are either ineffective or unreliable for deterring predation (Knowlton et al. 1999), but may limit food consumption (Polson 1983, Ternent and Garshelis 1999). Predation on sea turtle nests by raccoons in Florida was unaffected using conditioned taste aversion (Ratnaswamy et al. 1997).

Aversive conditioning may be effective in "teaching" brown bears to fear and avoid humans. Jonkel (1994:22) relates, "problem bears were captured and brought into holding facilities where they were repeatedly confronted by humans and repelled by chemical sprays. The captive process, called 'bear school', lasts only 4–6 days." For valuable endangered species, such as subspecies of brown bear, the expense of such a method (about \$6,000 per animal), may be necessary considering the alternative for problem bears is usually destruction of the animal (Jonkel 1994).

#### Electronic Training Collar

A relatively new device receiving attention as a nonlethal method to deter predation on livestock is an electronic training (shock) collar usually used for training domestic dogs (Andelt et al. 1999). Using captive coyotes, Andelt et al. (1999) reported the training sequence with the electronic collar stopped all attempted attacks on lambs, decreased the probability of an attempted attack. eliminated successive chases, and even caused avoidance of lambs. Application may be limited under field conditions because the predator must be captured and the training collar attached, but does suggest avenues of future research on response-contingent aversive stimuli that change the behavior of the predator during the attack phase of a predatory sequence (Andelt et al. 1999). Lending support to this concept, Nolte et al. (2003) used these collars on deer and successfully eliminated feeding in protected plots.

## Reproductive Interference

An interest in influencing the reproductive rate of coyotes with chemical sterilants dating to the 1960s assumed that reduced reproduction would reduce population levels and that fewer coyotes would result in tewer depredations (Balser 1964, Knowlton et al. 1999). Trials with diethylstilbesterol indicated reproduction among coyotes eould be curtailed (Balser 1964, Linhart et al. 1968), but timing was critical and the approach was impractical without effective delivery systems; given these limitations, research on this substance was eventually curtailed (Knowlton et al. 1999). Currently there is renewed interest in reproductive inhibition using immunocontraceptive agents (DeLiberto et al. 1998), mainly as a means of changing the predatory behavior of coyotes (Till and Knowlton 1983). Surgical sterilization (tubal ligation and vasectomy) of coyotes was effective in reducing predation rates on domestic lambs without affecting social behavior and territory maintenance (Bromley and Gese 2001a,b). Vasectomy of males has been proposed as a method of population control among wolves (Haight and Mech 1997). However, at present there are no substances available for predator fertility control that are species specific. Species specificity will have to be achieved through appropriately designed delivery

#### Livestock Protection Collar

The livestock protection collar (LPC) is a collar with an attached rubber pouch or bladder filled with Compound 1080. The device is placed around the neck of lambs and kid goats (Acorn and Dorrance 1998). Compound 1080 is an acute toxicant formerly used as a predacide and rodenticide. Most predacide uses were cancelled in 1972 because of nontarget hazards, and rodenticide uses were canceled in 1990 because technical registrants did not submit adequate data in support of Compound 1080 to the EPA (Fagerstone and Schafer 1998). The LPC is designed to kill coyotes when they puncture the bladders during an attack on a lamb or kid. The major advantage of LPCs is they selectively remove the problem animal and frequently kill individual predators that have evaded other control techniques (Connolly 1980. Connolly and Burns 1990, Blejwas et al. 2002). The LPC comes in 2 sizes (large and small), with the larger LPC working effectively on larger lambs (Burns et al. 1996). The major disadvantages of LPCs are initial purchase costs and labor required for application and maintenance (collars must be adjusted as animals grow), incidental puncturing of the collar (by thorns, wire, or other snags), anticipating which lambs or kids are most likely to be attacked, and record keeping

(accounting for the Compound 1080 in the collars) (Wade 1985, Acorn and Dorrance 1998. Knowlton et al. 1999).

#### M-44

The M-44 is a mechanical device that ejects sodium cyanide into the mouth of an animal after it pulls on the device (Connolly 1988. Acorn and Dorrance 1998). The unit consists of a case holder wrapped with cloth, fur, wool, or steel wool; a plastic capsule or case that holds the cyanide; and a 7-cm ejector unit (Dolbeer et al. 1994b). The M-44 case is loaded with 0.78 g of sodium cyanide and an additive to reduce caking. A spring-loaded plunger ejects the cyanide. When assembled, the components are encased in a tube driven into the ground. The cocked ejector with the case in the holder is screwed on top, placed into the tube, and baited with fetid meat, a lure, or tallow. When an animal is attracted to the bait and tries to pick up the baited case holder with its teeth, the cyanide is ejected into its mouth. Canids, skunks, raccoons, bears, and opossums sometimes are attracted to the bait used on M-44s; however, species specificity can be enhanced by proper site and lure selection (Acorn and Dorrance 1998). A study of coyotes in California found the M-44 was not a selective technique in targeting or removing the breeding animals involved in sheep depredations (Sacks et al. 1999a). The M-44 is registered and authorized by different agencies depending upon the country of use (e.g., Pest Control Products Act of Canada, U.S. Environmental Protection Agency) for control of coyotes, foxes, and feral dogs, and has numerous restrictions.

## Aerial Hunting

Aerial hunting is a commonly used method for reducing predator numbers (e.g., Wagner and Conover 1999). Various kinds of fixed- and rotary-wing aircraft have been used in control programs for wolves, coyotes, bobcats, and foxes (Wade 1976). Hunting is most effective with snow cover because the target animals can be more readily observed and tracked. When the specific animal is found, the pilot approaches at approximately 20 m of altitude, preferably into the wind. The ground speed of the aircraft is around 60–85 km/h, but the airspeed should not approach the stall speed of the aircraft. A 12-gauge semi-automatic shotgun is the most common weapon used, with number 4 buckshot, BB, and number 2 shot preferred.

Several modifications have been made to fixed-wing airplanes to increase safety and effectiveness, including a larger propeller and drooped wingtips to provide added power, lift, stability, and maneuverability (Dolbeer et al. 1994b). Larger balloon-type tires have been added to provide clearance for the longer propeller and to better use primitive runways for landings. Rotary-wing aircraft (helicopters) are also used in predator control. The helicopter, with its ability to hover, can be more effective in rough, brushy terrain. Visibility and tracking ability are improved in models with a Plexiglas bubble cockpit.

Fixed-wing aircraft and helicopters can be used cooperatively. The helicopter is used for tracking and dispatching the animal, while the fixed-wing aircraft flies above the helicopter and maintains surveillance. This combination works well in areas with thick vegetation or where animals have been hunted heavily with helicopters. Aerial hunting can be more efficient if a ground crew works with the air-

craft (Wade 1976). The ground crew induces coyotes to howl by using a horn, siren, voice, or recorded howl. When animals respond, the aircraft is directed to the area by 2-way radio communication. Early morning and late afternoon tend to be the most productive times for aerial hunting. Federal law requires each state where aerial hunting is allowed to issue aerial hunting permits. Some states also require low-level flying waivers.

#### Denning

Increased depredations of livestock (mainly sheep) and poultry during spring and summer by covotes and foxes usually indicate that a pair of coyotes or foxes has a litter of pups nearby. During spring and summer, adults will increase their predation rates for provisioning pups (Till and Knowlton 1983). In a study in Wyoming, sheep losses to coyotes were greatly reduced after removal of only the pups, and were similar to reduction in predation rate when both pups and adults were removed (Till and Knowlton 1983). Direct removal by digging or use of a chemical smoke cartridge is often used to destroy the pups (Acorn and Dorrance 1998). An alternative to denning is surgical sterilization of adult breeding coyotes, which worked as effectively as denning, with a long-term (several year) efficacy but without the requirement of finding the den (Bromley and Gese 2001a,b).

Dens are usually located by tracking or observing the adults, or use of simulated howling to get the pups to respond. Den hunting is often based upon the assumption that adults that kill livestock will return to the den via the most direct route possible. An active den is evidenced by hairs around the entrance, fresh tracks, and, if the pups are large enough to have emerged from the den, matted and worn vegetation around the entrance and small scats. Dens may also have prey remains lying about the den area.

Den hunting is difficult and time-consuming, particularly on hard ground and in heavy cover (Acorn and Dorrance 1998). Some people use a dog to aid in locating the den. A call imitating a frightened or injured pup sometimes will bring adult coyotes within range near a den site. Caution should be taken while digging out dens because of the possibility of cave-ins and ectoparasites. These hazards can be eliminated if a gas cartridge is used to kill the pups in the den. At times an aircraft is used to locate coyote and fox dens. From the air, signs of an active den include cleaned-out holes and trampled vegetation.

#### Traps

Live traps of variable construction are available from several companies in a variety of sizes and configurations to capture small, medium, and even large predators such as bears. Problem bears can be caught in a live trap made from steel culverts equipped with a trap door and trigger device, and mounted on a trailer permitting personnel to easily relocate the bear (Dolbeer et al. 1994b). Generally, coyotes, foxes, and bobcats are difficult to live trap because of their cautious nature and reluctance to enter confined areas.

Canned dog or cat foods are effective baits to entice raccoons, opossums, skunks, and cats into live traps. As described by Dolbeer et al. (1994b), traps for skunks can be covered with a canvas or heavy cloth and provided with a flap for the door. When a skunk is captured, the trapper can approach the trap on the covered side and carefully drop the flap over the door, allowing the skunk to be transported to the release site. To release it, the trapper should stand beside the trap and ease the flap and door open; the door may need to be propped open to allow the animal to leave when it is ready.

Foothold or steel traps are manufactured in a variety of sizes (Fig. 13B, C, D. F). Modification of traps (e.g., padded jaws) and attachment of a trap tranquilizer device can greatly diminish injuries to the animal (Sahr and Knowlton 2000). Tension devices should also be considered to minimize captures of nontarget species (Phillips and Gruver 1996). Selectively removing the offending animal causing the depredations with a trap can be difficult (Sacks et al. 1999a). The following trap sizes are recommended:

- #0 and 1: weasels and ground squirrels;
- #1 and 1½: skunks, opossums, mink, feral cats, and muskrats;
- #2 and 3: foxes, raccoons, small feral dogs, nutria, marmots, and mountain beavers:
- #3 and 4: bobcats, coyotes, large feral dogs, badgers, and beavers;
- #4 and 4½: wolves; and
- #4½ and 114: mountain lions.

Success in trapping depends on placing the trap along travel ways, such as along dirt roads and trails. As described by Dolbeer et al. (1994b) a trap usually is set in the ground by digging a shallow trench the size of the trap and deep enough to allow the stake (or drag) and chain to be placed in the bottom of the hole and covered with soil. The trap is set firmly on top of the buried chain and should be about 11 mm below the soil surface. A piece of canvas, cloth, mesh screen, or a plastic sandwich bag is placed over the pan to prevent soil from getting beneath the pan and preventing its depression. The trap is then covered with soil and other material natural to the area in the vicinity of the trap. The trap can be set unbaited in a trail; this is called a "blind" or trail set. Traps also may be set off the trail and baited with a lure, bait, or natural substance, such as scat or urine (a dirt-hole set). The latter is effective for raccoons, foxes, and mink. The trap is set in the same manner as the blind set, but instead of placing the scent on the ground, the lure is placed in a small hole (about 15 cm deep) dug behind the trap. Lure selectivity for the target species is important. The location of a set also influences its selectivity. When placed beside a carcass, a trap can catch nontarget animals such as vultures (Cathartes aura, Coragyps atratus), eagles, badgers, and other nontarget predators. Many states no longer allow trapping in the vicinity of a carcass. Weather also can impact operation of traps, with frozen or wet ground preventing a trap from springing.

Foothold traps must be checked often to minimize time captured animals are restrained. Most states have regulations on types of traps, baits, sets, and trap visitation schedules. Some states no longer allow use of foothold traps; state and local regulations should be consulted prior to conducting any trapping activity.

## Calling and Shooting

Calling and shooting can be a selective means to control coyotes, bobcats, and foxes. Calling and shooting, with or without help of lure dogs, can be a selective means of removing offending coyotes that kill livestock, particularly during denning and pup-rearing seasons (Coolahan 1990, Sacks et al. 1999a). Several commercial calls and recorded calls are available from a variety of manufacturers or outlets. The call is blown to imitate the sound of a rabbit in distress. This sound either arouses the predator's curiosity or indicates an easy meal. However, some predators become wise to calling. Conversely, the call may be an effective method to remove a trap-wise animal. Calls imitating a pup in distress can also attract the adults. Generally, 3 factors should be considered to successfully call in a predator: (1) ensure the caller is downwind from the area being called to prevent the predator from detecting the caller's scent before the animal comes into shooting range (2) within limits imposed by terrain and vegetation, acquire a full view of the area so the predator will be unable to approach unseen, and (3) avoid being seen by wearing camouflage clothing and hiding in vegetation (Acorn and Dorrance 1998). The most effective times to call predators are early morning and late afternoon. The hunter can gain an added advantage by locating an animal before beginning to call by inducing howls. Calling at night and using a spotlight (where legal) can also be effective.

# Hunting Dogs

Two types of dogs can be used for lethal predator control. Dogs that hunt by sight, such as greyhounds, can be kept in a box or cage until the predator is seen, then released to catch and kill the animal. This type of dog is effective only in relatively open terrain. The other type of dog is the trail hound, which follows an animal by its scent. Trail hounds hunt on bare ground; however, snow or heavy dew makes trailing easier. Hot, dry weather makes trailing difficult; therefore, early morning is the most effective time to hunt with trail hounds. Several breeds, such as bluetick, black and tan, Walker, and redbone, in packs of 2-5 dogs are most commonly used. Trained trail hounds are used to catch and "tree" raccoons, opossums, bobcats, bears, and mountain lions. Often these dogs are able to track a depredating predator from a kill, making this control method highly selective. State and local regulations should be consulted prior to hunting with dogs.

#### Snares

Snares are made of varying lengths and sizes of wire or cable looped through a locking device that allows the snare to tighten. There are generally 2 types of snares: body and foot (Fig. 13A, G). As described by Dolbeer et al. (1994b), the body snare is used primarily on coyotes and foxes. This snare is set where an animal crawls under a fence, at a den entrance, or in some other narrow passageway. The snare is placed so that the animal must put its head through the noose as it passes through the restricted area. When the snare is felt around the neck, the animal normally will thrust forward and tighten the noose.

The spring-activated foot snare has been used to capture large predators (Bacus 1968, Logan et al. 1999). As described by Dolbeer et al. (1994b), when the animal steps

on the trigger the spring is released, propelling the noose around the foot. The animal instinctively recoils, tightening the snare cable around the foot. The foot snare can be used in a bear pen or cubby set. A bear pen is just large enough to accommodate the bait, which usually is the carcass remains of an animal killed earlier by the predator. The pen can be built of brush or poles and has an open end where the snare is set. The pen and guide sticks force the bear to step into the snare while trying to reach the bait. Bears also can be caught with a foot snare in a trail set.

The foot snare also can be used to capture mountain lions (Logan et al. 1999). The snare should be set in a narrow trail known to be traveled by the target animal. Deer and livestock can be prevented from interfering with the snare with a pole or branch placed across the trail, directly over the set about 0.9 m above the ground.

Selectivity of the foot snare may be improved by placing sticks under the trigger that break only under the weight of heavier animals (Dolbeer et al. 1994b). Opencell foam pads can be placed under trigger pans to prevent unintentional triggering of snares by small mammals (Logan et al. 1999). Foot snares have advantages over large bear traps in that they are lighter, easier to carry, and less dangerous to humans and nontarget animals.

#### SUMMARY

Wildlife damage management is one of the fastest growing segments of the wildlife profession. Wildlife damage can no longer be viewed as only an agricultural problem. As human and wildlife populations grow, the number of conflicts and their severity also increase. Continual human expansion into rural and remote areas and the ability of some wildlife species to continually adapt and thrive in proximity to human society assures that the number and magnitude of conflicts will keep increasing. Many wildlife conservation issues are related to wildlife damage, particularly the impact of some predators on certain threatened and endangered species (e.g., coyotes killing endangered kit foxes), or mediating the impact of an endangered species on a human resource (e.g., reintroduced wolves killing livestock). As observed by Conover (2002), when humans and wildlife conflict, both are losers. The goal of this chapter has been to examine the current state of wildlife damage management, addressing the main issues and means of mediating damage between wildlife and human interests. New issues will continually come to the forefront and additional means to manage them will be required. Research to add more tools to the wildlife damage management "toolbox" is required. Development and evaluation of socially acceptable, primarily nonlethal, means to reduce damage are needed, especially in the wake of the banning of traditional tools in some areas. The challenges facing wildlife damage management professionals are not only biological and ecological. changes in values related to wildlife damage management are occurring. Some suggest this is due to the public's ignorance and disconnect with the natural world, while others may view it as an ethical responsibility to care for the occupants of our natural world. Professionals in this field must continue to be as versed in human dimensions (social, political, legal, and economic) aspects of human-wildlife conflict as they are with the biological and

ecological aspects. Thus, it is important that university curriculums offer classes on wildlife damage management, so that we properly prepare and educate future wildlife professionals to face the challenges they will experience.

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